CHAPTER 4

PAVEMENT REHABILITATION

400.00 INTRODUCTION

Rehabilitation generally involves restoring the ride to a new condition, repairing surface problems such as cracking, rutting and pothole patches and providing good skid resistance. To accomplish this may require overlaying, milling, recycling, grinding, crack sealing and/or joint sealing, as well as, other activities associated with a preservation, widening or in rare cases a reconstruction project. Designs for rehabilitation differ from new construction in that considerable information about the pavement structure and performance already exists. In addition, structural capacity can be measured with deflection equipment. Rehabilitation design guides are based on deflection measurements augmented by experience and do not directly follow the new AASHTO Design Guide. Table 400.00-1 shows the data required for a rehabilitation design. In addition the designer should be familiar with the traffic loading information presented in Chapter 2, as well as, the cost data compiled by Contracts and Specifications Services. As in pavement design for new construction, rehabilitation designs should reflect the most cost effective solution although life cycle cost analysis would not routinely be conducted.

400.01 FLEXIBLE PAVEMENT REHABILITATION

The procedure used to design overlays in Arizona is to determine the structural adequacy by deflection testing. When the 18k equivalent loading is less than 100,000 for the design period, deflection testing and design is rarely warranted; therefore deflection testing and analysis is not required for those projects. Except in unusual situations, the design period for overlay/rehabilitation projects is 10 years and the corresponding ten year traffic loading is used for design. For divided highways or highways with four or more lanes, the design traffic for the high traffic lane is reduced by ten percent for each additional traffic lane. The other traffic lanes are therefore each ten percent of the design traffic. Generally, milling out some depth of asphalt bound material in each traffic lane and replacing with new or recycled AC is more cost effective than a simple overlay. Mill out depths and overlay thicknesses can be determined from deflection measurements. Typically three to five measurements per mile are taken in each traffic lane using the falling weight deflectometer (FWD) or dynaflect.

TABLE 400.00-1

DATA REQUIRED FOR DIFFERENT TYPES OF CONSTRUCTION PROJECTS

Data Required	Reconstruction	Widening	ACP Rehabilitation	PCCP Rehabilitation	Surface Treatments
Existing As-Built Information	H	H	H	H	H
Roughness, Skid,Cracking (Type & %)	L	M	H	H	H
Field Data	H	H	H	H	H
Pavement Surface Condition	L	M	H	H	H
Traffic Data (ADT & ADL)	H	H	H	M	L
Subgrade Sampling & Testing	H	M	L	L	N/A
Deflection Testing	L	H	H	M	L
Material Sources	H	H	M	M	L
Environment & Drainage	H	H	M	M	L

Level of Need: H = High M = Moderate L = Low N/A = Not Applicable

Materials Section uses the SODA (Structural Overlay Design for Arizona) method, which is based on analysis of all 7 FWD or 5 dynaflect sensor readings.

A. SODA METHOD

The SODA method uses as input values:

1) Total traffic loads expected over the design period (18 kip ESAL's) for the given lane.

2) Road roughness (Mays-meter value)

3) Seasonal Variation Factor

4) Spreadability Index (SI) (Section 301.01.C.4)

5) FWD #7 or Dynaflect #5 sensor readings

The equation for thickness is:

$$T = \frac{(\mathrm{Log}\ L - 3.255) + (0.104 * SVF) + \left[\dfrac{0.000578 * (Po - 4.255)}{0.54}\right] - (0.0653 * SIB)}{0.0587 * \left[2.6 + (32.0 * D5)\right]^{0.333}}$$

Where:
- L = Design 18 kip ESAL's
- SVF = Seasonal Variation Factor
- Po = Roughness, inches/mile
- SIB = Spreadability Index before Overlay
  - For the FWD
  - $SIB = 2.7 * (FWD\ SI)^{0.82}$
- D5 = #5 Dynaflect sensor reading in mils
  - For the FWD
  - $D5 = 0.16 * (FWD\ D7)^{1.115}$

The thickness should be determined at each test location and the mean value of thickness for all test locations in a design section is then used as the overlay thickness. No statistical manipulations are needed as they were incorporated into the development of the method.

Any individual test location results less than zero are assigned a value of zero and any results over 6 inches are assigned a value of 6 inches.

If milling is involved then the roughness is set to 50 inches per mile. In addition the spreadability index before overlay is calculated to be a function of the depth of milling, representative of the new or recycled asphaltic concrete that will be placed in the milled out trench and is set equal to the SIM value in the following equation.

$$SIM = (0.899 * ET) + SIB$$

$$ET = \left[2.6 + (32 * D5) \right]^{0.333} * MILL$$

Where: SIM = Spreadability Index after milling and replacement.
ET = Equivalent thickness adjusted to reflect milling and replacement.
MILL = Depth of mill out and replacement in inches.

B. OTHER SODA CONSIDERATIONS

From past experience if the #7 FWD sensor reading is less than 0.67 mil, or less than 0.1 mil for the #5 dynaflect sensor, the thickness of the overlay probably will be too thick. Given the other physical distress measurements, such as ride and/or cracking the designer may elect to reduce the overlay thickness to a value sufficiently thick to meet or exceed Table 400.01-1 guidelines.

If the #7 FWD sensor is greater than 2.4, or the #5 dynaflect sensor is greater than 0.4, the subgrade is weak and the overlay thickness may be underestimated. For this case historical soil support logs, R-value tests and drainage should be investigated. Increased thickness and/or subgrade drainage may be necessary.

If the SODA design thickness is less than 2.5 inches or the traffic is less than 100,000 18 kip ESAL's, the designer should review the pavement management data base, the design review team data and design recommendation, as well as, personal project review notes in light of Table 400.01-1. This table contains the most common type of repair activities and range of thickness for a particular distress. The selected design should consist of a sufficiently thick overlay and/or mill and replace section to meet or exceed Table 400.01-1 guidelines.

C. OVERLAYS OTHER THEN SODA

There may be circumstances where an overlay is warranted for reasons of stage construction, continuity (widening, structures) or preventative maintenance. For these cases a minimum two inch overlay should be considered.

TABLE 400.01-1

OVERLAY GUIDELINES

When SODA overlay is 2.5 inches or less
or traffic loading less than 100,000 18 Kip ESAL's

ROUGHNESS:

Satisfactory	0-93 in/mile	No Action or Seal Coat
Tolerable	94-142 in/mile	2" Overlay
Objectionable	143+ in/mile	Minimum 2.5" Overlay

NOTE: See Table 400.01-2 for additional leveling thickness.

PERCENT CRACKING:

Low	Less than 10	No action or Seal Cracks
Medium	10-30	2" Overlay with or without milling
High	Greater than 30	Minimum 2.5" Overlay with or without milling

NOTE: Consider special treatments for reflective cracking.

MU-METER NUMBER:

High	43-99	No action
Medium	35-42	ACFC or Seal Coat
Low	Less than 35	ACFC or Seal Coat

NOTE: Milling should also be considered.

RUT DEPTH:

Low	0-.25 in.	No action
Medium	.26-.50 in.	Minimum 2" mill out and replacement
High	.51+ in.	Minimum 2.5" mill out and replacement

ANNUAL MAINTENANCE COST (PER LANE MILE):

Low	$0-333	No action
Medium	344-666	Minimum 1.5" Overlay
High	Greater than 666	Minimum 2" Overlay

NOTE: If patching material unstable milling will be necessary.

In addition to overlay thickness, the designer should consider the use of a special treatment to alleviate a troublesome problem. Large transverse or longitudinal cracks are difficult to control with just an overlay and can produce a reflective cracking problem. Special treatments such as asphalt rubber, fabrics or elastic tape material should be considered. Reflective cracking may also occur if the overlay thickness or the combined thickness of mill and replace pavement plus the overlay is less than the thickness of the remaining or existing old pavement. In order to reduce the incidence of reflective cracks, either the overlay thickness or milling thickness should be increased to be at least equal to the thickness of the remaining or existing old pavement. If this is not practical, then other special treatments such as asphalt rubber or fabric should be considered. Rutting problems may not be alleviated by just overlaying, milling of unstable material should also be considered. Bleeding pavements may also need to be milled in conjunction with the surface treatment. If cracks have been sealed by maintenance with asphalt rubber, they should be milled off before overlay to improve the overlay ride. To correct ride or rutting problems by only overlaying, a leveling quantity as shown on Table 400.01-2 should be specified.

Recycling of either milled material or stockpiled salvaged AC from other projects should be considered on all overlay projects. If recycling is not possible, but milling is necessary, milled material can be either stockpiled or used for shoulder buildup. Unusual drainage problems, such as springs, should be addressed with pavement reconstruction incorporating a drainage layer and/or geotextile separation layer. If swelling soil is in evidence then waterproof membranes such as asphalt rubber or a geomembrane to intercept water should be considered.

400.02 RIGID PAVEMENT REHABILITATION

Concrete structural damage, which may be evidenced by random cracks, should be determined from deflection testing. Figure 400.02-1 indicates the maximum deflection at the center of slab for a new plain jointed concrete pavement. This figure can be used to determine qualitatively the degree of structural damage and the type of rehabilitation to be considered (as shown on Table 400.02-1). If an overlay is warranted only minor slab repairs should be considered and normally only spalled joints would be repaired with AC patching material, no joint sawing or sealing would be necessary.

Other concrete surface distress problems such as rough ride (with or without faulting) or low skid resistance also create a need for rehabilitation. Table 400.02-2 shows typical

TABLE 400.01-2

LEVELING REQUIREMENTS ON OVERLAY PROJECTS

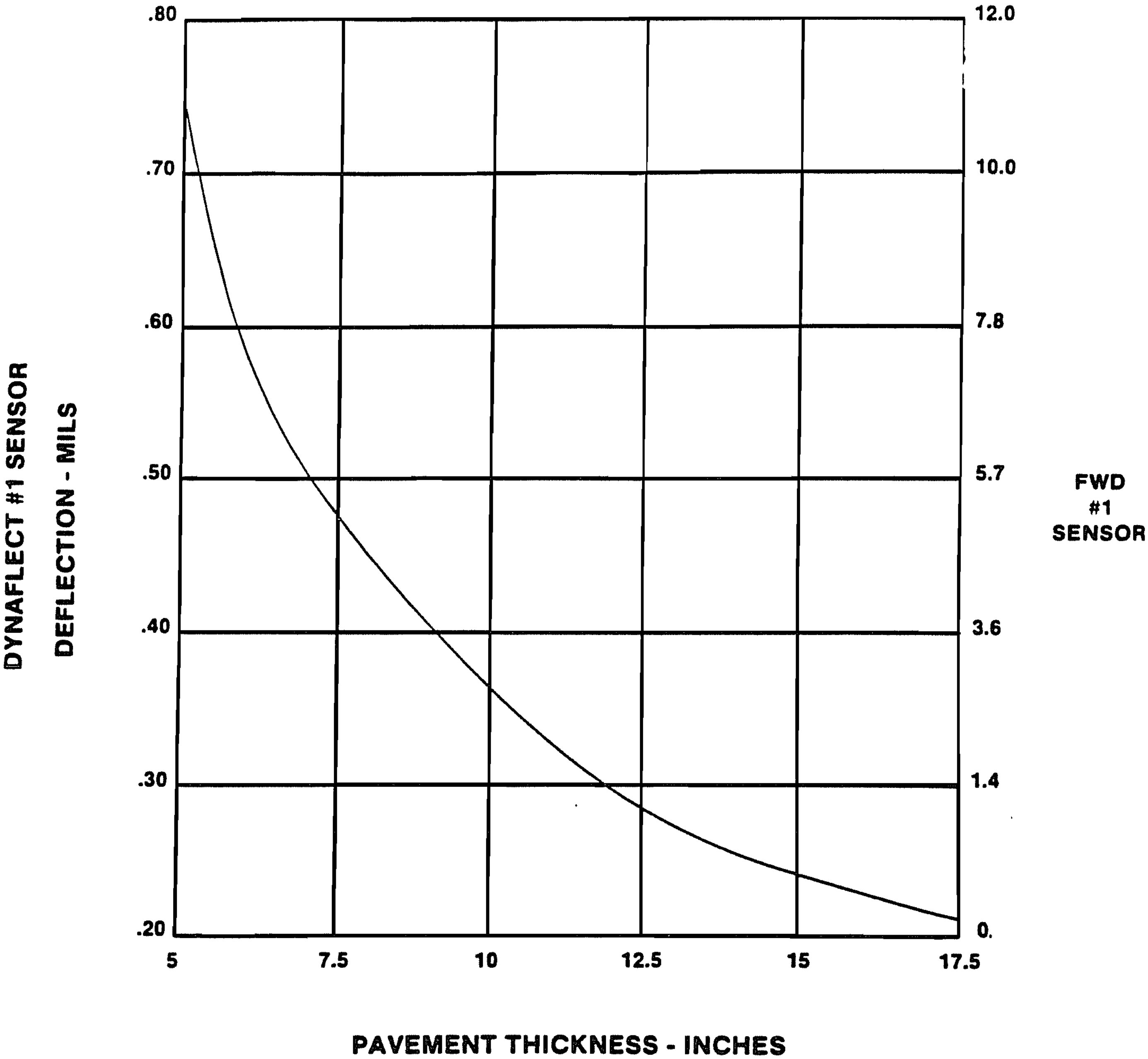
ROUGHNESS (MAYS)	ADDITIONAL THICKNESS FOR LEVELING IN INCHES	IN FEET
0 - 93	0 - 1/4	0 - 0.02
94 - 142	1/4 - 1/2	0.02 - 0.04
143 - 193	1/2 - 3/4	0.04 - 0.06
194+	3/4+	0.06+

RUT DEPTH	*LEVELING REQUIRED PER LANE (TONS/MILE)
1/4 Inch	50 Tons
1/2 Inch	100 Tons
3/4 Inch	150 Tons
1.0 Inch	200 Tons
1 1/4 Inch	250 Tons
1 1/2 Inch	300 Tons

*Leveling Based on a Three Foot Rut Width

FIGURE 400.02-1

DEFLECTION
VS
PCC PAVEMENT THICKNESS



$$\text{DYNA} = 3.6\left(\frac{1}{\text{THK}}\right) \qquad \text{FWD} = 76.6\left(\frac{1}{\text{THK}}\right) - 4.94$$

TABLE 400.02-1

CONCRETE STRUCTURAL REHABILITATION

Deflection* Ratio	Rehabilitation Action
1.0 or Greater	No structural damage
.99-.71	Consider asphalt rubber overlay, or minimum five inch AC overlay with or without break and seat, or membrane interlayer.
.7 or Less	Consider asphalt rubber overlay, or minimum six inch AC overlay with or without break and seat, or membrane interlayer, or total replacement.

* Ratio of new concrete deflection from Figure 400.02-1 to in service field deflection.

NOTE: Break and seat refers to mechanically cracking or breaking the PCCP slab into approximately two foot square pieces followed by rolling or seating the cracked PCCP with a heavy (40 ton) roller.

In areas with a seasonal variation factor of two or higher, edge drains should be considered.

Structural rehabilitation analysis generally is only considered if significant random cracks are present.

TABLE 400.02-2

CONCRETE NON-STRUCTURAL REHABILITATION

Ride Roughness	Rehabilitation Action
0-93 in/mile	No action
94+ in/mile	Grind* or three layer asphalt rubber overlay or asphalt rubber overlay

Skid Resistance	
43 or more	No action
35-42	Groove*
Less than 35	Groove*

* Joints would be sawn and resealed.

NOTE: Localized spalled areas at joint should be patched. In addition, slabs with significant cracking may need to be repaired or replaced.

rehabilitation methods to be considered. If the concrete is to be ground or grooved and there are asphalt shoulders, concrete shoulders of at least seven inch thickness should be considered.

400.03 WIDENING

Some projects may involve widening the existing highway together with overlaying or mill out with replacement. If the widening is less than a full lane (12 feet) or of a temporary nature (intersection, or stage design) then the existing pavement and pavement structure should be used to design the overlay and widening. Normally the widening would match the in place structural number or minimum structural number, whichever is greater. The full width overlay or mill out plus overlay would be determined by the flexible overlay method, Section 400.01. If no overlay is needed, at least a minimum thickness (two inches) would be placed for continuity.

If the widening was one lane or wider and at least 1500 feet long, it would be designed in accordance with section 202.00. The remaining in-place pavement would be designed in accordance with section 400.01, except it would be a twenty year design and would be considered the inside lane. Thus the new widening would be designed with 90 percent traffic loading and the overlay with 10 percent traffic loading. If possible, the total thickness of the new AC and base should closely match the thickness of the existing pavement section. If the existing pavement did not need an overlay then at least a minimum thickness (two inches) would be placed for continuity.